ENVIRONMENT AGENCY

South West Region.

Gunnislake Fish Counter.

The River Tamar in spate at Gunnislake Weir – December 1999.

Annual Report 1999.

Cornwall Area Fisheries Science Team
March 2000.

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Executive Summary

The following report presents the daily upstream counts of migratory salmonids recorded at Gunnislake Weir fish counting station (SX 435 713) situated on the River Tamar in 1999. The counter data contained within this report covers the period of the commercial migratory salmonid net buy-back scheme and the implementation of the National Spring Salmon Byelaws. These were in operation on the following dates in 1999:

- Net buy-back - 8 August to 31 August 1999, inclusive
- National Spring Salmon Byelaws – 15 April to 31 May, inclusive

The fish counter at Gunnislake is a resistivity based system (Logie 2100A – Aquantic limited) and is installed in the fish pass on the Cornish bank of the River Tamar at the head of the tide.

The minimum salmon count for 1999 was 2691. Overall, this indicates that the salmon run in 1999 was 14% lower than that recorded in 1998 (3132) and is the second lowest count recorded over the last 6 years. A breakdown of the 1999 salmon run into the two main run components reveals the following:

- A 4% increase in the numbers of multi sea winter "spring" salmon (March – May) when compared to 1998 figures and a 3% decrease when compared to the 5 year average.

- A 15% decrease in the numbers of one sea winter "grilse" (June – November) when compared to 1998 figures and a 24% decrease when compared to the 5 year average.

The 1999 upstream count for sea trout was 13145 and is the largest count recorded for sea trout over the last 6 years. This equates to a 36% increase in the total number of sea trout recorded when compared to the 1998 data (8375).

The run pattern observed for salmon and sea trout in 1999 was generally consistent with that of previous years. However, the total combined annual count of salmon and sea trout migrating upstream on the River Tamar in 1999 was 25% higher than the 5 year average (1994 – 1998).

The fish counter hut at Gunnislake was washed off its foundations during a flood on 18/19 December 1999. Fish counter data is therefore unavailable from 13 December to the end of 1999. The hut has now been replaced and recommissioning of the fish counter was completed at the beginning of April. The fish counter has been fully operational and collecting data since Thursday 6 April.

1. Introduction

The following report presents upstream salmon and sea trout counts with respect to daily mean flow (cumecs) recorded during 1999 at Gunnislake fish counting station (SX 435 713) on the River Tamar. The flow data reflects the residual flow that exists at Gunnislake weir following abstraction by South West Water (SWW).

The report also includes details of the on-going counter validation work and the annual audit of counter data. This is primarily used to assess counter efficiency and to develop improved methodologies for species apportionment.

2. Background

Fish counters, such as the one installed at Gunnislake Weir, are increasingly becoming essential tools in the management of salmonid fisheries. They provide vital baseline data on the size of the migratory salmonid populations and information on the times during which their migrations occur. This information used in conjunction with other fishery data, such as juvenile survey data and rod / net catches, significantly enhances the formulation of effective management strategies.

The current fish counter at Gunnislake weir is a resistivity-based system (Logie 2100A) manufactured by Aquantic Ltd. The counter was installed in 1992 and validated during 1993 and 1994.

The fish counter at Gunnislake is situated on the River Tamar at the head of the tide and is installed in the fish pass on the Cornish bank of the gauging weir at Gunnislake. The fish counter operates over a single channel, 1.6 metres in width, via 3 stainless steel electrodes. The electrodes are incorporated into the downstream face of a 'Crump' sectioned weir, which is contained within the fish pass.

Radio tracking studies conducted in 1994 / 1995 indicated that 75% of salmon migrated up into the freshwater Tamar utilising the Cornish bank fish pass. The remaining 25% were assumed to have used the Devon bank fish pass or ascended the weir when high spring tides coincided with high water levels – Solomon *et al* (1999).

The counter at Gunnislake is one of two resistivity-based systems operated by the Cornwall Area Fisheries Science Team. The other counter is located on the River Fowey at Restormel Weir (SX 107 613).

A description detailing the operation of the resistivity fish counter at Gunnislake is provided in Appendix 1.

3. Net Buy-Back

National byelaws to protect stocks of 'spring' salmon were introduced on the 15 April 1999. The implementation of these byelaws effectively restricted the salmonid-netting season on the River Tamar from 1 June – 31 August, inclusive.

As in 1997 and 1998, South West Water (SWW) operated a buy-back of commercial migratory salmonid netting time within the Tamar estuary. In 1998, it switched from 2

March – 7 June to 8 August – 31 August, inclusive. This put a further limit on the times available for netting, effectively restricting the netting season to 1 June – 7 August. The main aim of the SWW buy-back scheme is to mitigate for the construction of Roadford reservoir and was originally timed to assist in the conservation of multi sea winter fish. It now mainly protects the grilse run.

4. Species Apportionment

The counter has the ability to record electrical changes that are directly proportional to the size of fish that have traversed the counter electrodes. Species apportionment is possible due to the linear relationship that exists between fish length and deflection size. However, it is not possible to distinguish between a salmon and a sea trout of comparable size. It is therefore inevitable that the salmon count may include some large sea trout. As this situation is most likely to exist between March and the end of June, a data handling protocol has been developed to minimise this eventuality. This is described in Appendix 2.

5. Validation of counter efficiency

Initial validation studies were carried out in 1993 and 1994, to assess counter efficiency. The counter was re-validated in 1998 and counter data is now audited, using video footage taken over the weir, on an annual basis. Counter events are matched up with video events, which can then be used to assess the efficiency of the counter and to investigate anomalies in the counter data.

Video validation and the annual audit of counter data is a vital part of the fish counter work at Gunnislake and gives confidence in the accuracy of the data that the fish counter is recording. A complete description of the video validation strategy and methodology is described in Appendix 3.

6. Results

The migratory salmonid counts obtained for the River Tamar recorded at Gunnislake fish counting station in 1999 are presented as follows:

6.1. Upstream Fish Counts

Figure 1: Presents the monthly upstream counts for salmon recorded at Gunnislake weir in 1999. The total number of salmon counted moving upstream in 1999 was 2691 (Table 1).

Figure 2: Presents the monthly upstream counts for sea trout recorded at Gunnislake weir in 1999. The total number of sea trout counted moving upstream in 1999 was 13145 (Table 2).

Figures 3 & 4: Presents the daily upstream counts for salmon and sea trout, in relation to monthly mean flow (cumecs) at Gunnislake weir in 1999.

Figures 5 – 28: Each of these figures presents daily upstream counts for salmon and sea trout, for each month, in relation to daily mean flow (cumecs) recorded at Gunnislake weir.

Note:

- To aid in interpretation of the data, axis scaling may differ between the monthly summary plots. Care should therefore be taken when interpreting the data within each figure.

- The flow data presented is the residual flow that exists at Gunnislake weir. This has been calculated by subtracting the Daily Mean Abstraction (DMA) from Daily Mean Flow (DMF) data.

Figure 1 – Monthly Upstream Counts for Salmon at Gunnislake Weir 1994 – 1999.

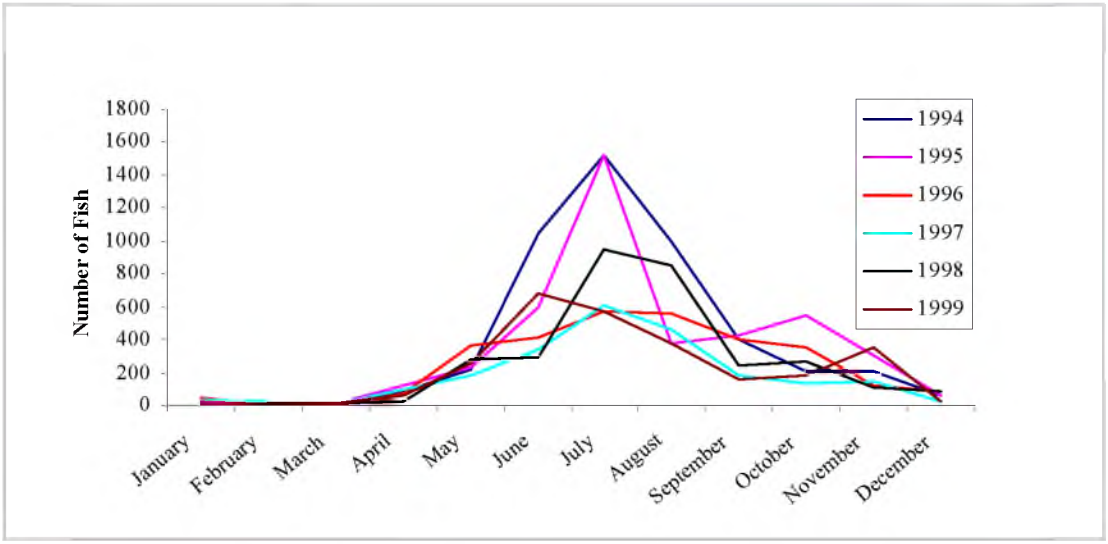


Table 1 - Monthly Upstream Counts for Salmon at Gunnislake Weir 1994 – 1999.

Month	1994	1995	1996	1997	1998	1999
January	15	22	45	32	6	11
February	3	6	1	27	9	3
March	6	11	1	8	7	16
April	90	116	76	95	30	60
May	222	234	360	185	283	257
June	1042	591	409	342	295	683
July	1520	1525	576	603	949	571
August	1000	376	557	464	850	374
September	397	427	400	185	244	160
October	211	552	354	133	268	177
November	204	303	126	142	109	350
December	59	65	86	26	82	29
Totals	4769	4228	2991	2242	3132	2691

Figure 2– Monthly Upstream Counts for Sea Trout at Gunnislake Weir 1994 – 1999.

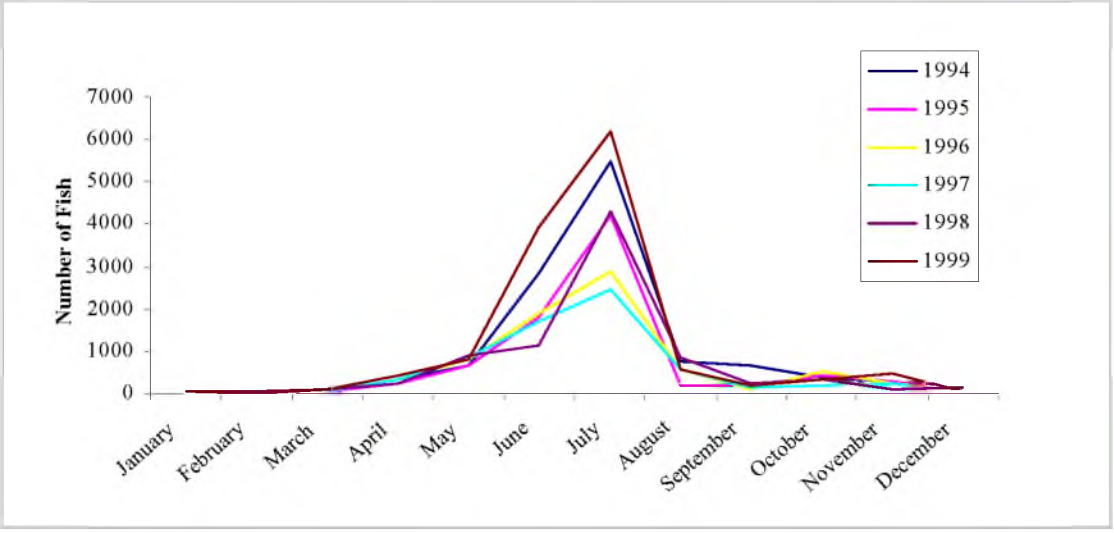


Table 2 - Monthly Upstream Counts for Sea Trout at Gunnislake Weir 1994 – 1999.

Month	1994	1995	1996	1997	1998	1999
January	32	17	51	22	34	28
February	2	12	8	62	59	11
March	55	59	49	65	71	116
April	329	221	313	333	217	411
May	653	659	817	835	921	826
June	2841	1807	1875	1724	1131	3927
July	5478	4190	2868	2440	4311	6207
August	748	206	556	548	838	549
September	661	181	78	127	237	191
October	377	438	529	194	354	338
November	275	284	230	220	82	482
December	51	78	78	62	120	59
Totals	11502	8152	7452	6632	8375	13145

7. Discussion

Figures 1 and 2 indicate that the seasonal run patterns observed for salmon and sea trout on the River Tamar in 1999 were consistent with previous years. However, there was a 25% increase in the combined annual total count for upstream migrating salmonids on the River Tamar when compared to previous years. This increase is almost certainly a reflection of the increase in sea trout numbers and more particularly school sea trout.

7.1. Salmon counts recorded on the River Tamar 1995 - 1999.

As with many of the other rivers in the South West, the salmon run on the River Tamar usually begins in April / May and continues until the end of November / beginning of December. The larger multi sea winter 'spring' salmon are generally the first component of the salmon run to be seen, followed by the higher numbers of one-sea winter fish, grilse. The grilse component of the stock is most prevalent in the period June - August.

The minimum salmon count estimate for 1999 was 2691. Overall, the salmon run estimate for 1999 was 14% lower than in 1998 (3132) and is the second lowest count on record. The lowest was recorded in 1997 (2242). The salmon counts for 1999 are up on the 5-year average for only four months (March, May, June and November) and 24% down on the 5-year average overall.

A breakdown of the 1999 salmon run data into the two main run components is as follows:

- Count figures indicate that the 333 multi-sea winter "spring" salmon counted between March – May 1999 represented a 4% increase in the size of this component of the salmon run, in comparison to figures for 1998. Comparisons to the 5-year average (345) for the same period shows that there has been an overall drop of 3% in the size of the multi-sea winter 'spring' salmon component of the salmon run.

- The counter data indicates that the 2315 grilse counted between June – November 1999 represents a 15% decrease in the grilse component of the total salmon run estimate, when compared to 1998 figures. Comparing this to the 5-year average (3030) over the same period shows that there has been a 24% reduction in the size of this component of the salmon run.

The slight increase in the multi-sea winter 'spring' component of the run is encouraging; the count for multi-sea winter fish (333) is the third highest count figure for this period over the past 6 years. However, comparisons with the 5-year average still indicate that, overall, the numbers of these 'spring' fish are still declining.

Conversely, for grilse, 1999 was a poor year. The minimum count estimate for the period June to November (2315) is the second lowest recorded over the past 6 years. The significant decrease in the size of grilse component of the 1999 run in comparison with the 5-year average must be a cause for concern.

The count figures for the grilse component of the run in early October are on average lower than would be expected in comparison with data for previous years. The total count for the month is the second lowest recorded for the period over the last 6 years. This lack of fish movement would appear to reflect the low river flow conditions around this time. This has almost certainly deterred the fish from moving up into the freshwater Tamar and is also reflected in the count data for sea trout. However, around the 22 October, counts start increasing again with the count data indicating that there was a sudden large influx of fish, which extended into November. This influx of fish contributed to 57% (201 salmon) of the total salmon count for November and corresponded to an increase in river flow over the same period.

7.2. Sea Trout Counts Recorded on the River Tamar 1995 - 1999.

Historically, the main sea trout run on the River Tamar is consistent with that of many other rivers in the South West and is concentrated predominantly in the months of June and July. Traditionally, the sea trout run begins in May with the peak movement, predominantly school peal, taking place in June and July. Smaller runs occur in April, May and August with numbers declining sharply near the end of August with only small numbers moving upstream thereafter.

The counter data indicates that 1999 was an exceptional year for sea trout (13145). The minimum run estimate for 1999 shows a 36% increase on the 1998 estimate (8375) and is the largest count recorded over the 6 years of counter operation. The previous highest count was in 1994 (11502).

The majority of the run was concentrated in June and July and, although the pattern of the run is similar between years, the numbers of fish moving are well above the 5-year monthly average. The minimum count estimates for sea trout in March (116), April (411), June (3927), July (6207) and November (482) were the highest recorded over the last 6 years. The previous highest counts were recorded in 1994 (June & July), 1995 (November), 1997 (April) and 1998 (March). May had the third highest count recorded over the past 6-year's (826). The highest count for this month was recorded in 1998 (921).

The increase in sea trout numbers and the more modest increase in the numbers of spring salmon could be due to one or a combination of favourable factors. The introduction of net buy-back schemes over the past few years will undoubtedly have allowed a greater proportion of the fish to enter the freshwater Tamar. The same situation does not seem to be true for grilse and may be the result of poor survival rates or high exploitation \ predation at sea.

The counts in December are lower than expected as the counter was out of action from the 18 December 1999 until the end of the year. Count data was lost from the 13 December. This was due to the fish counter hut and its associated equipment being washed away in a flood. It is unlikely that a reliable estimate for the lost count data could be made from the data collected around this period and from previous years. In any case, counts recorded prior to the counter being out of action, together with data from previous years suggests that the numbers of fish traversing the weir are likely to be relatively low and would therefore have little effect on the overall run patterns.

7.3. Other Species.

There was a large run of sea lamprey (*Petromyzon marinus, L*) in May and June, and a two upstream and one downstream migrating shad (*Alosa sp.*) were seen on the surface skimming camera in August. The majority of these events were identified from counter data and video footage and the counts were adjusted accordingly to remove these species from the salmonid count.

7.4. Flows on the River Tamar 1995 - 1999.

The pattern of flow recorded at Gunnislake gauging station in 1999 was generally consistent with that of previous years. The extended period of low flows, which were particularly evident from the end of June until the beginning of October 1999, may have deterred fish from moving upstream. However, Figures 3 and 4 show that the daily mean residual flow did not fall below the migration index for Gunnislake fish pass (2.3 cumecs). The migration index represents the flow below which the migration of salmonids is considered to be inhibited - Solomon *et al* (1999).

7.5. Video Validation and Counter Efficiency

All of the video footage taken at Gunnislake during 1999 was taken during the hours of daylight.

Table 3 – Summary of Video Validation at Gunnislake Fish Counter 1999.

Camera	No. of Hrs. Recorded	Period of Operation	No. of Hrs. Watched	Fish Counted	
				Salmon	Sea Trout
Downward Facing Camera	1110.03	4/5/99 - 18/9/99	209	56	1054
Surface Skimming Camera	742	6/8/99 - 24/10/99	40	24	127

The counter efficiencies are based on the number of fish that have been seen on video and recorded by the counter during daylight hours over the period (5/5/99 – 18/9/99).

The overall detection efficiency of the counter for upstream migrating fish was estimated at 90% in 1993. The analysis of the 1999 data indicates that the counter was working at an equally high level of efficiency for upstream migrating fish. Slight losses in efficiency were present for sea trout. However this was due to the large numbers of sea trout passing over the weir in groups of two or more. In many cases these were recorded as single fish counts or as "non-fish" events, which resulted in an under estimate for sea trout.

8. Data Processing

The data presented in this report represents final adjusted counts, which take into account such things as maintenance work on the fish pass and non-target species. Weir cleaning was initiated in May 1998. Data from 1998 and from previous years, was not affected by this activity.

The original monthly summary reports distributed in 1999 were intended to give a general indication of salmonid movements and to provide an estimated minimum salmonid count for each month. Any data contained within the original monthly summary reports has been superseded by this report.

9. Update

- A telemetry system was installed at Gunnislake early in 1999. This has enabled the counter to be remotely downloaded and operational conditions to be closely monitored. It has also allowed us to quickly identify and rectify faults with the counter, and has resulted in a further reduction of the enforced downtime for 1999.

- A Year 2000 compliant counter was installed at the site on the 14 July 1999. The software and computer were tested for compliance on 14 May and 29 September respectively and subsequently verified as compliant. No problems have been found with the counter during the roll over into the year 2000.

- On 18/19 December 1999, an unusually large flood event occurred on the River Tamar which resulted in the fish counter hut at Gunnislake being washed away. The fish counter unit with its associated ancillary equipment and the electrical infrastructure of the counter hut became completely submerged for approximately 24 hours. The hut and the equipment were all recovered but were damaged beyond repair. The site required a complete re-wire of the fish counter hut and a replacement fish counter and laptop computer. The fish pass ancillaries, such as the motor unit (Rotorque) on the fish pass gate, also required electrical testing and/or replacement, as did the integrity of the cabling out to the fish pass ancillaries and fish counter electrodes. The hut is now back in place and the counter was back in operation and collecting data on Thursday 6 April 2000.

Photo 1 – Gunnislake Fish Counter Hut Stuck in the Trees after the Flood.

Photo 2 - Inside View of Gunnislake Fish Counter Hut after the Flood.

10. Future Work

- Continued validation of the counter's performance and efficiency will be carried out on an annual basis using side aspect and overhead video cameras.

- Identification of adipose fin-clipped salmon tagged as part of the continuing CEFAS smolt-tagging programme that is being undertaken on the River Tamar. This study has been undertaken to assess marine survival and, in particular, exploitation within the Irish drift net fishery.

- To assess the presence and abundance of non-target species traversing the fish pass e.g. Shad (*Alosa sp.*), Sea Lamprey (*Petromyzon marinus*) and Mullet (*Mugil sp.*).

- Replacement of the existing downward facing camera with a high quality monochrome digital camera. This will improve the picture quality in both the daytime and the night-time video footage.

- An upgrade of the 12V infrared lighting system to a more powerful 240V system is in progress and should be completed by the end of April 2000. The new system consists of two 300-Watt infrared lights, which should give good light penetration of the water and will improve the quality of both night and day time footage.

- As in 1999, an experimental surface skimming camera will be installed in time for the main run of fish in 2000. The camera was installed at the beginning of August in 1999, primarily to identify fin clipped fish as part of a smolt-tagging project, in collaboration with CEFAS. The preliminary analysis of the video data from last year was very encouraging and shows that the camera is good for accurate species identification. Results also suggest that the camera can be used in conjunction with counter data to improve species apportionment and it has already been used to identify both upstream and downstream migrating shad (*Alosa sp.*)

- Two sensors / data-loggers, designed to measure and record changes in temperature and barometric pressure at hourly intervals, will be installed at the counter site in March 2000. These are being installed to investigate the effects of temperature and pressure on the movements of salmonids. These will provide valuable additional data, which can be used in conjunction with the counter, flow and video data to improve our knowledge of salmonid movements on the River Tamar.

- Installation of a Hard Disk Video Recorder (HDD VCR), which can be programmed to capture images of fish passing over the weir only when a fish passage event is occurring i.e. triggered by the fish counter. If successful, this will dramatically reduce video-watching times, as footage will only be collected when an event is occurring. The video will run in parallel with a conventional time-lapse video, which will act as an audit for the HDD VCR video data.

11. Downtime

The counter was operational for 8280 hours out of a possible 8760, approximately equivalent to 345 days out of a total of 365 days. The majority of this downtime can be attributed to the counter hut being washed away in the flood on 18 December 1999. The downtime is broken down as follows:

Table 4 – Breakdown of Counter Downtime in 1999.

Item	*Downtime*		*% Downtime*	
	Enforced	*Routine*	*Enforced*	*Routine*
Weir cleaning (gate shut)	2.3	4.57	0.48	17.51
Counter Maintenance	0	2.70	0.00	10.34
Camera Maintenance	0	18.60	0.00	71.26
Counter Fault	49.50	0.00	10.23	0.00
Other	432	0.23	89.29	0.88
Total Downtime (Hours)	483.80	26.10		
Expected Operational Hours	8760.00			
% Time Operational	94.18			

12. References

01. Environment Agency (1997). Design and Use of Open Channel Resistivity Fish Counters (Advisory Manual). Fisheries Technical Manual No. 2. Environment Agency North West Region. R&D Technical Report W23.

02. Environment Agency (1997). Salmon and Sea Trout Movements Recorded at Gunnislake Fish Counting Station on the River Tamar during 1996. Environment Agency. Annual Report 1997.

03. Environment Agency (1998). "A Preliminary Assessment of the Buy-back of licensed Migratory Salmonid Netting Time on the River Tamar in 1997 and 1998. Environment Agency. Gunnislake Fish Counter Data Report - July 1998.

04. Solomon, D.J, Sambrook, H.T, Broad, K.J (1999). Salmon Migration and River Flow: "Results of Tracking Radio Tagged Salmon in Six Rivers in South West England." Research & Development Publication 4. Environment Agency 1999.

05. Environment Agency (1998). Gunnislake Fish Counter. Annual Report 1998. Environment Agency 1999.

Figure 3 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir 1999.

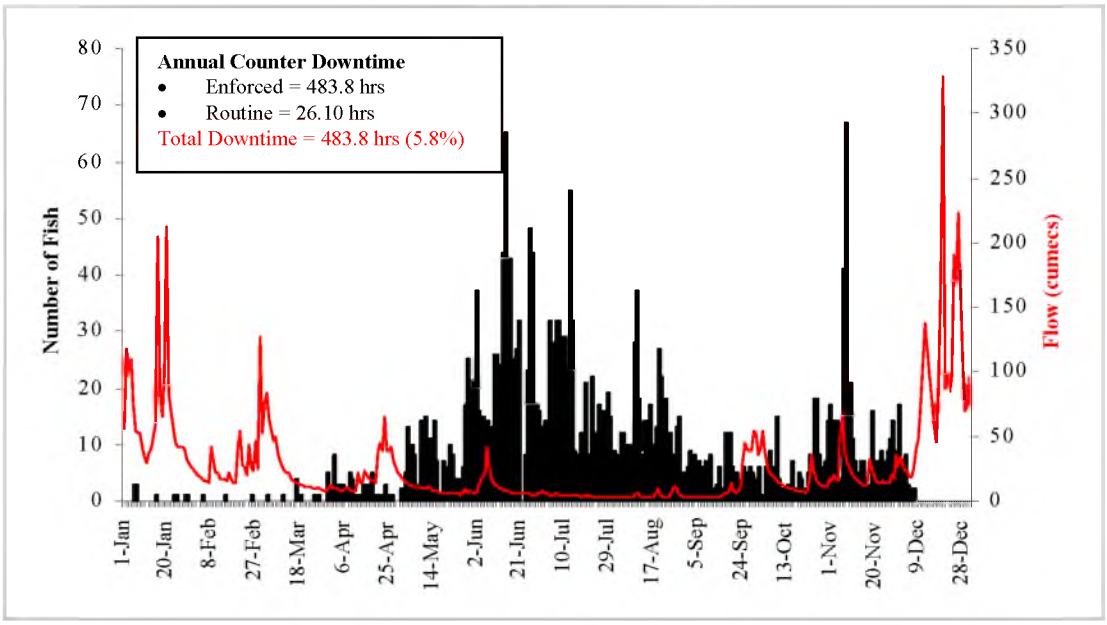


Figure 4 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir 1999.

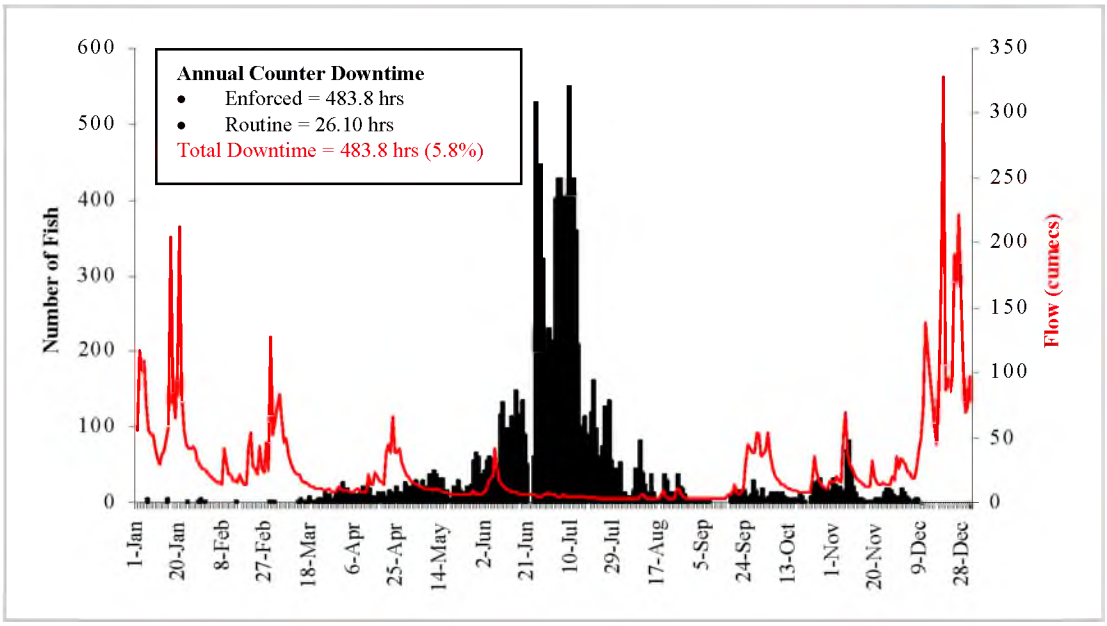


Figure 5 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – January 1999.

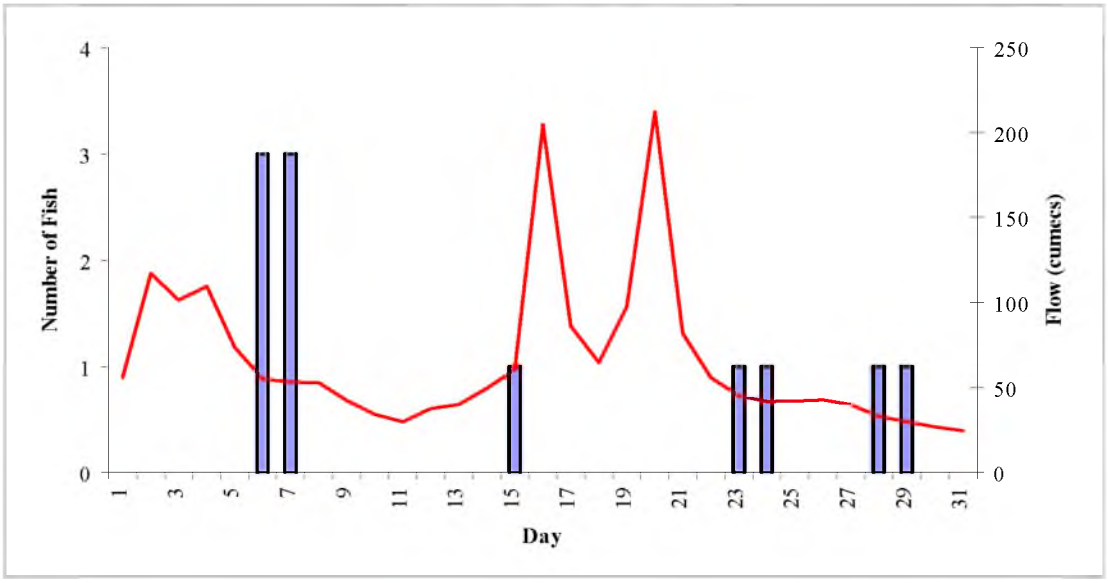


Figure 6 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – January 1999.

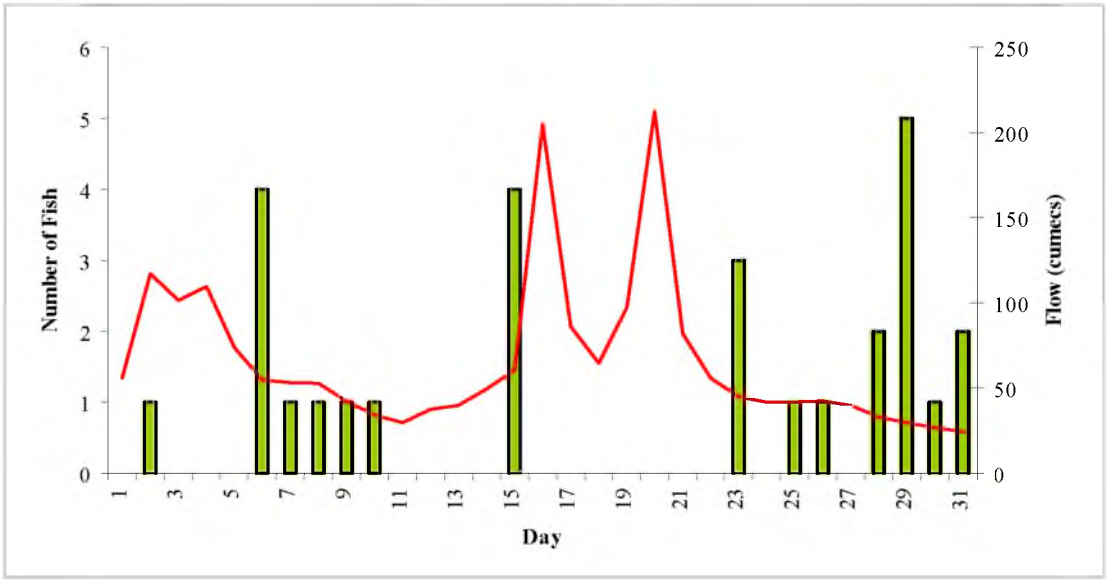


Figure 7 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – February 1999.

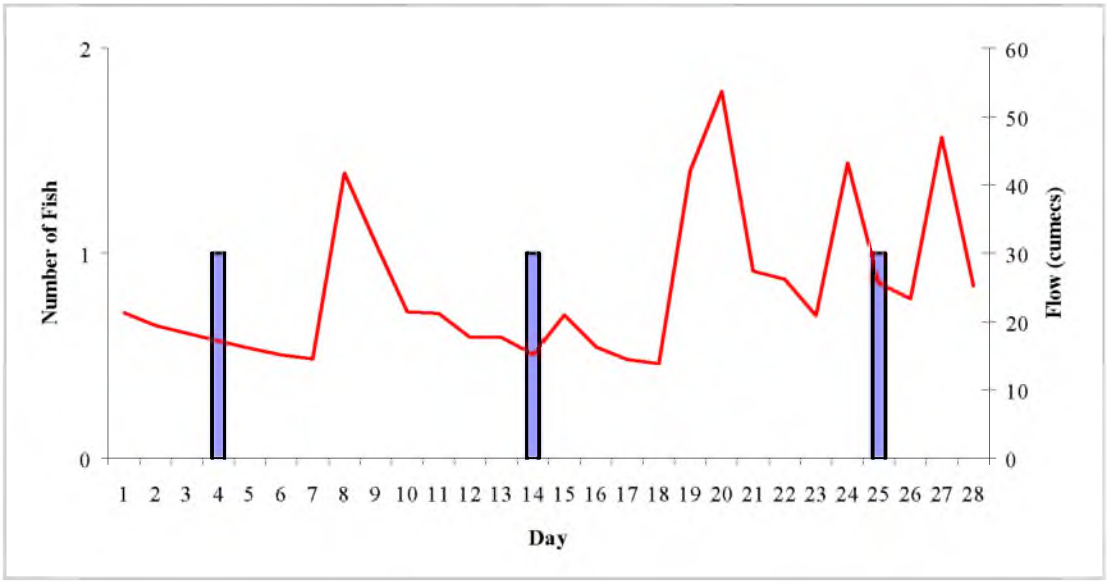


Figure 8 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – February 1999.

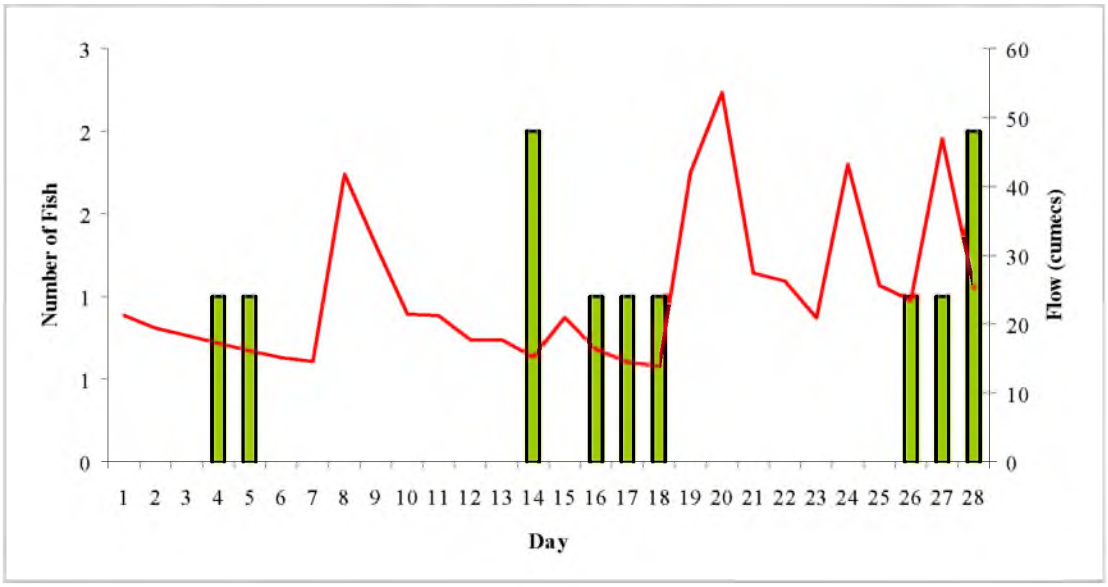


Figure 9 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – March 1999.

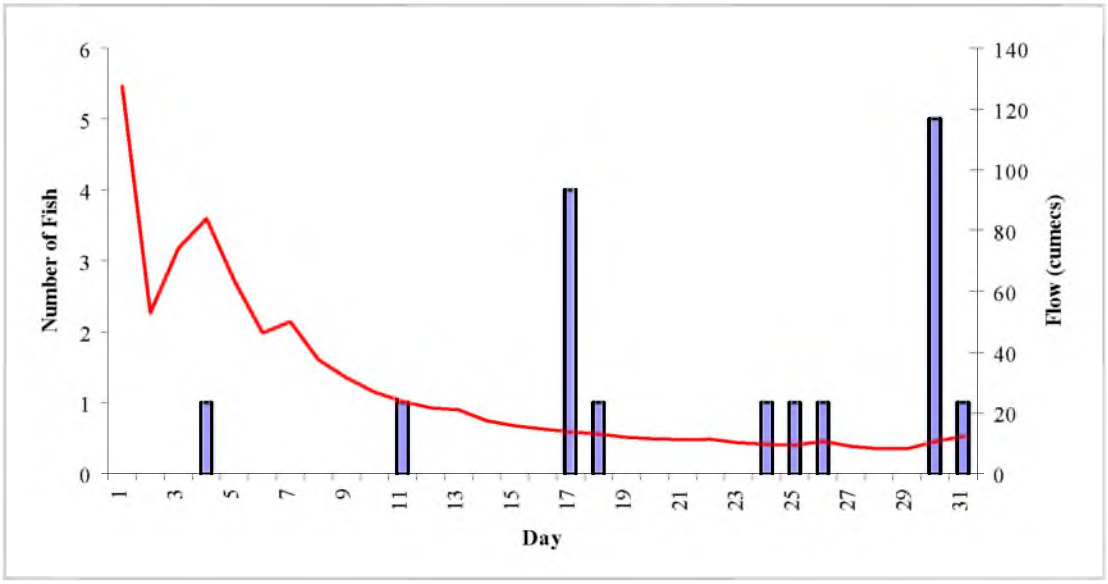


Figure 10 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – March 1999.

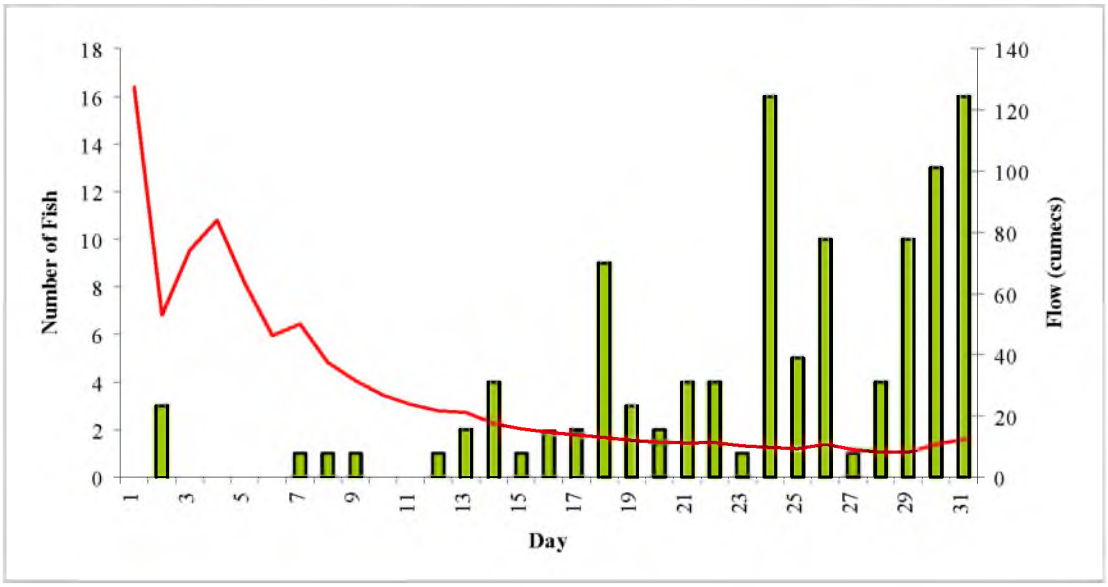


Figure 11 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – April 1999.

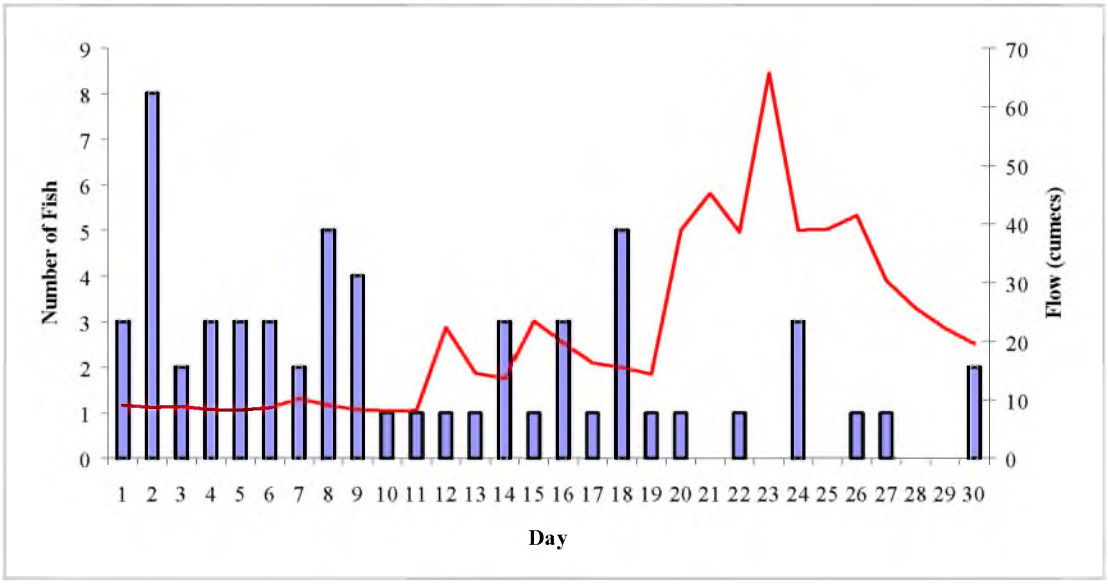


Figure 12 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – April 1999.

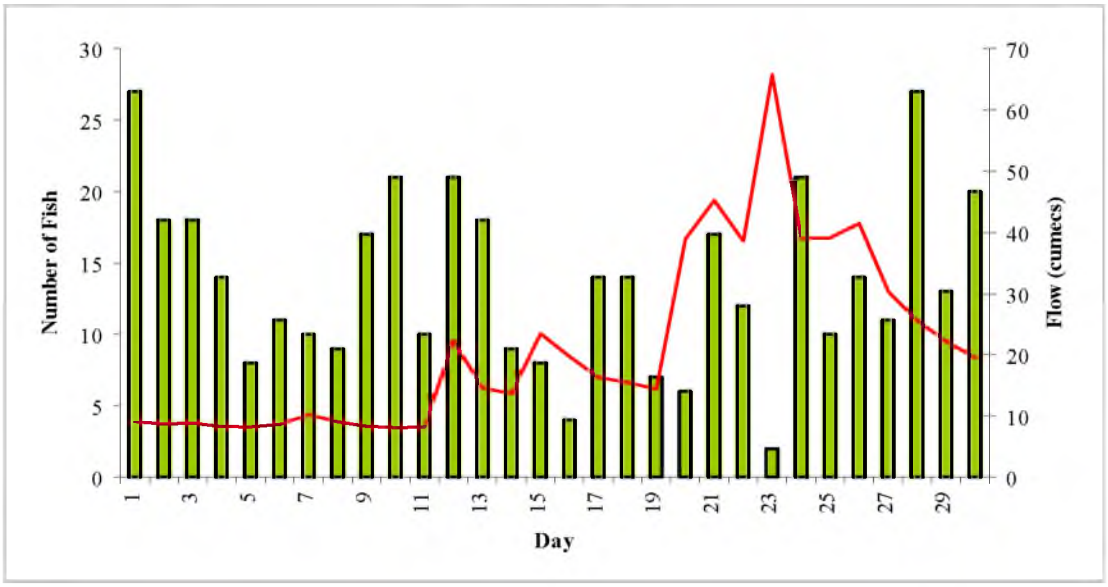


Figure 13 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – May 1999.

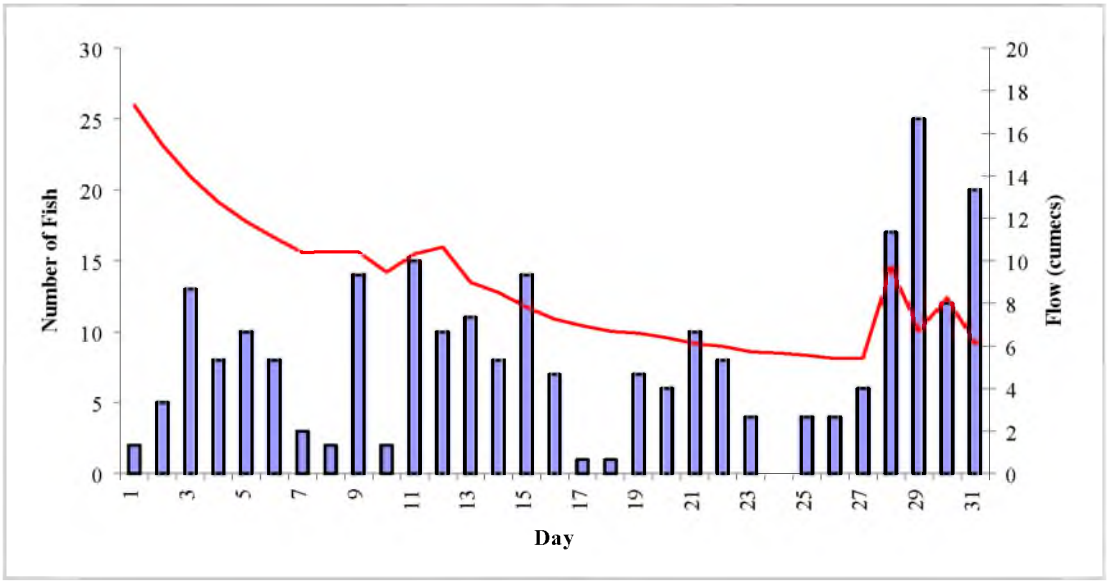


Figure 14 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – May 1999.

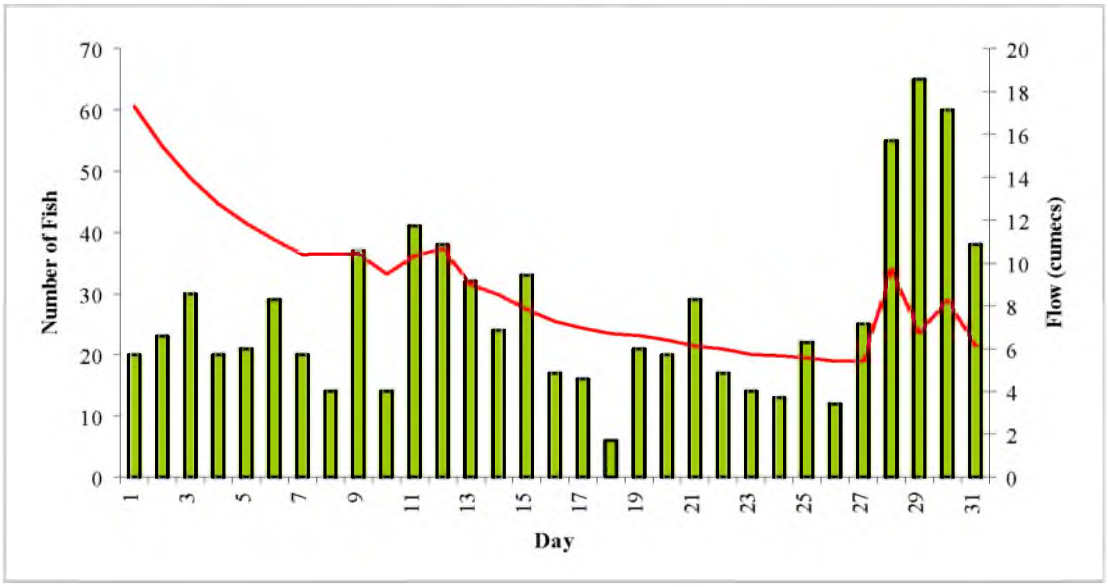


Figure 15 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – June 1999.

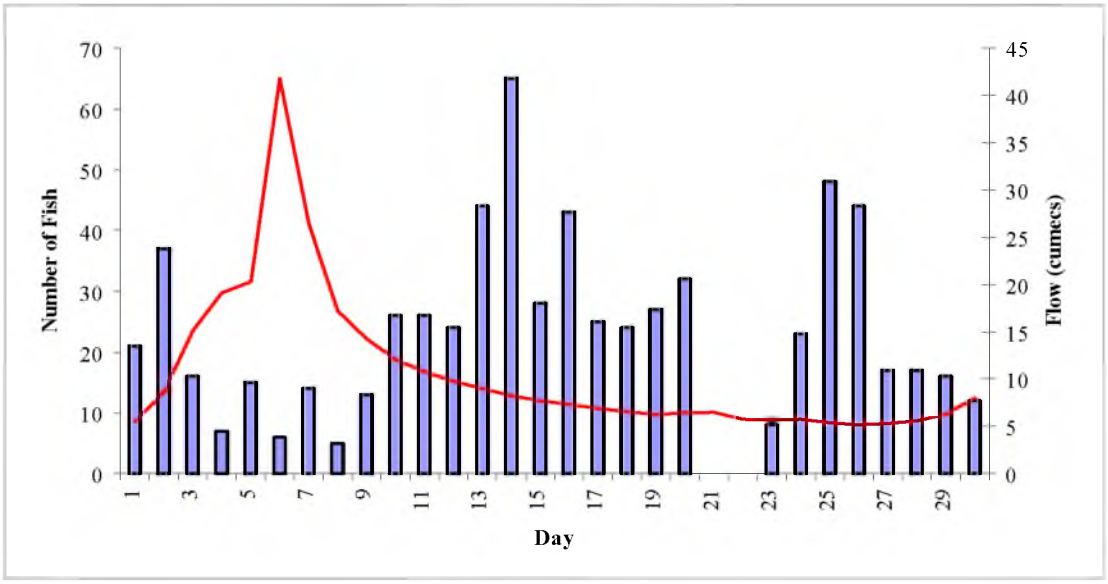


Figure 16 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – June 1999.

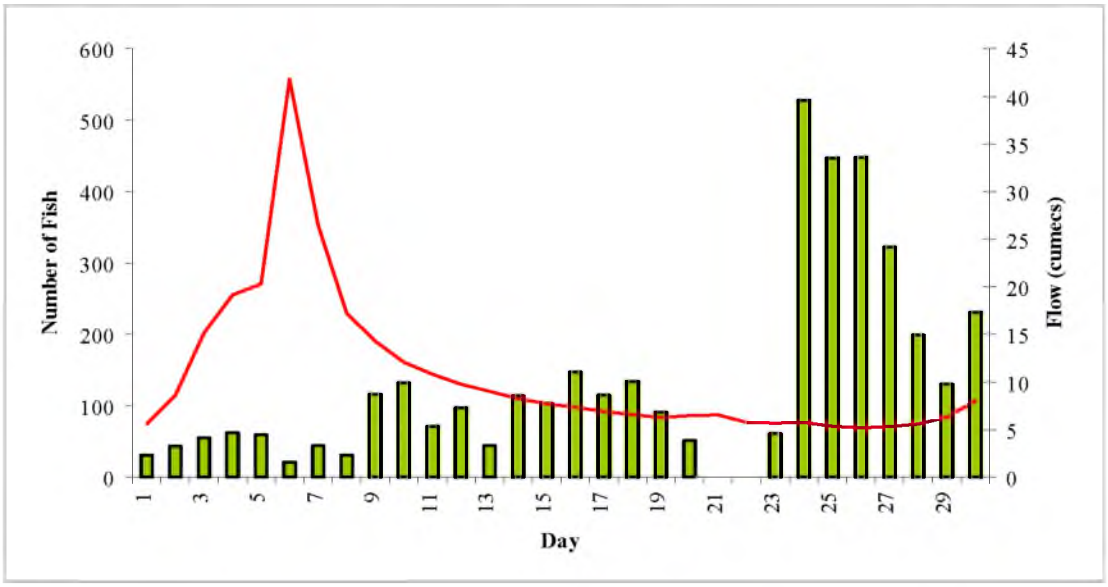


Figure 17 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – July 1999.

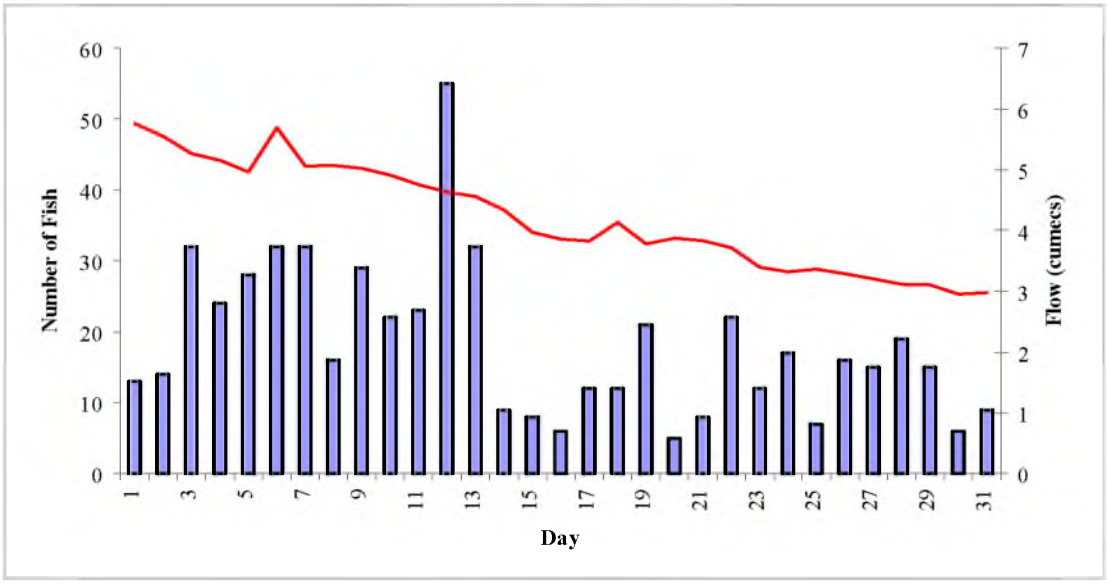


Figure 18 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – July 1999.

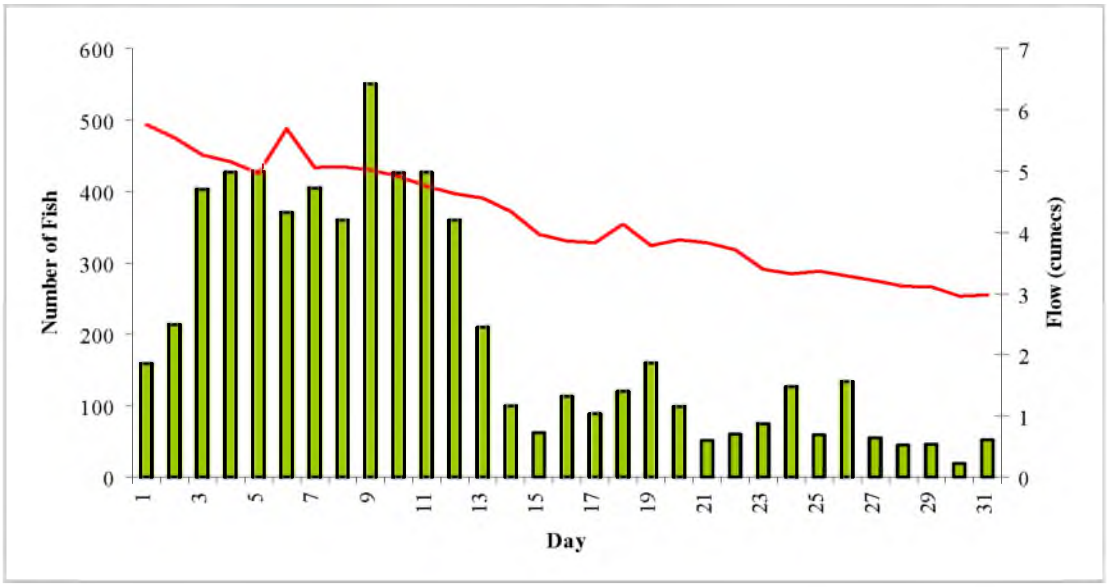


Figure 19 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – August 1999.

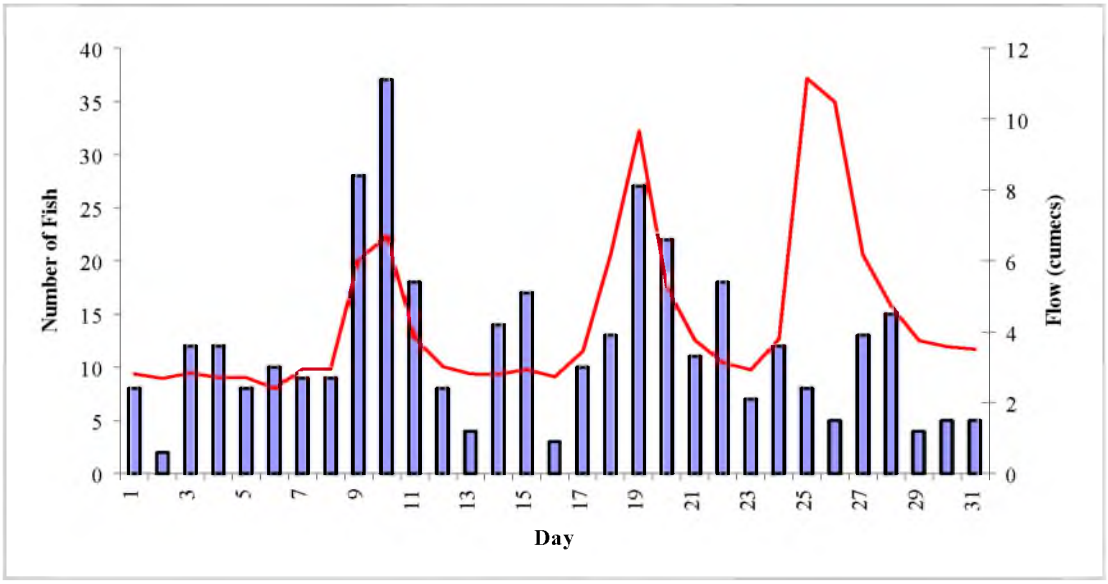


Figure 20 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – August 1999.

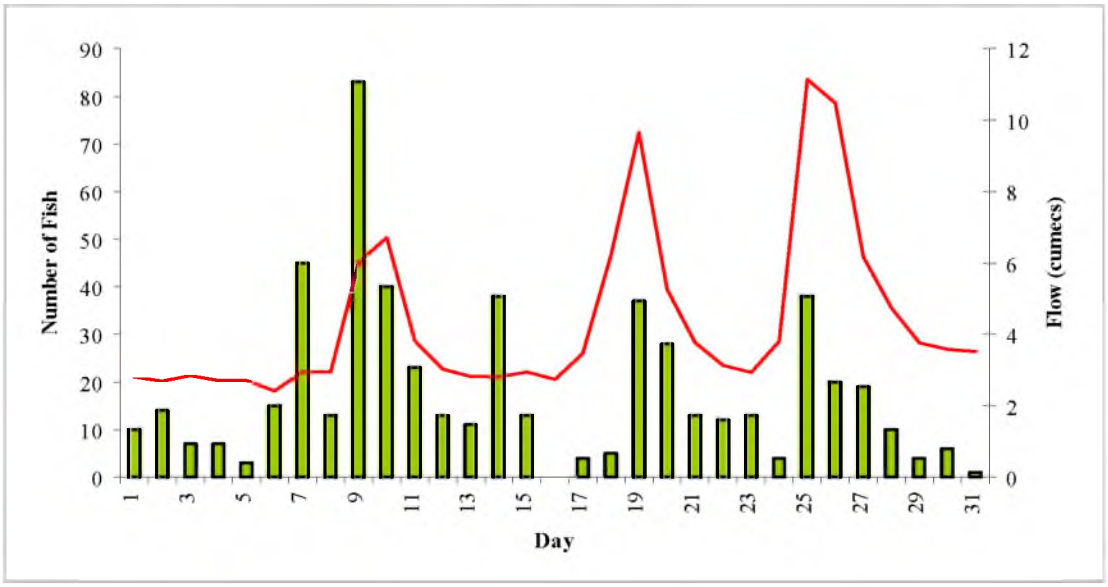


Figure 21 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – September 1999.

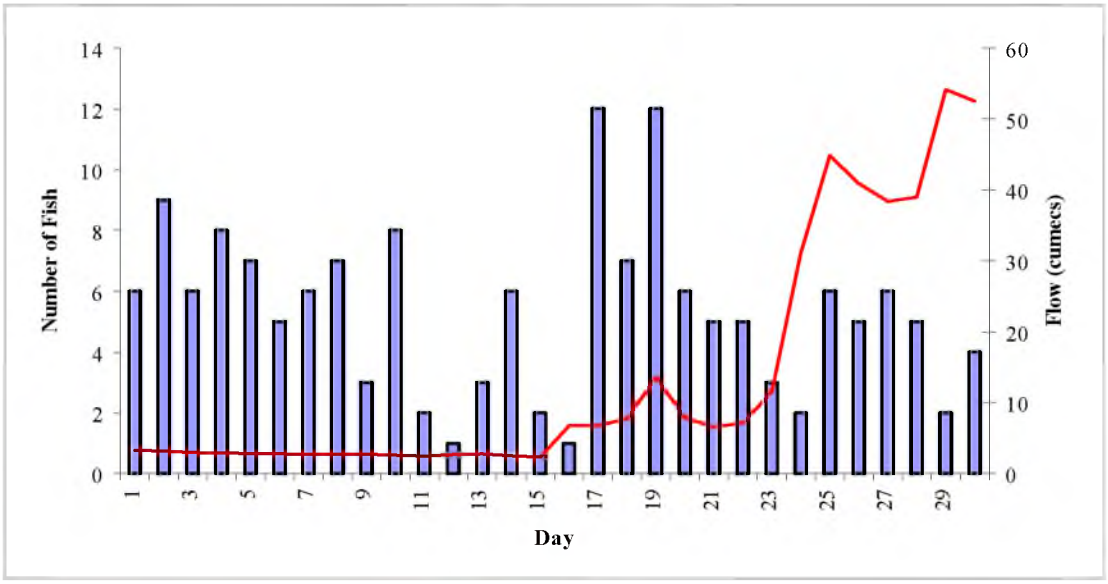


Figure 22 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – September 1999.

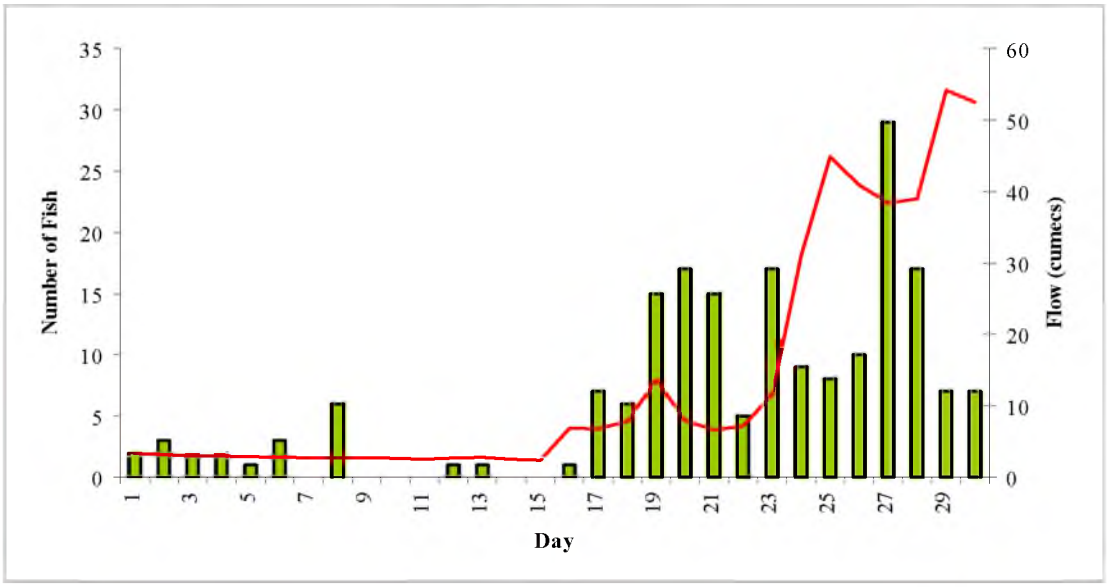


Figure 23 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – October 1999.

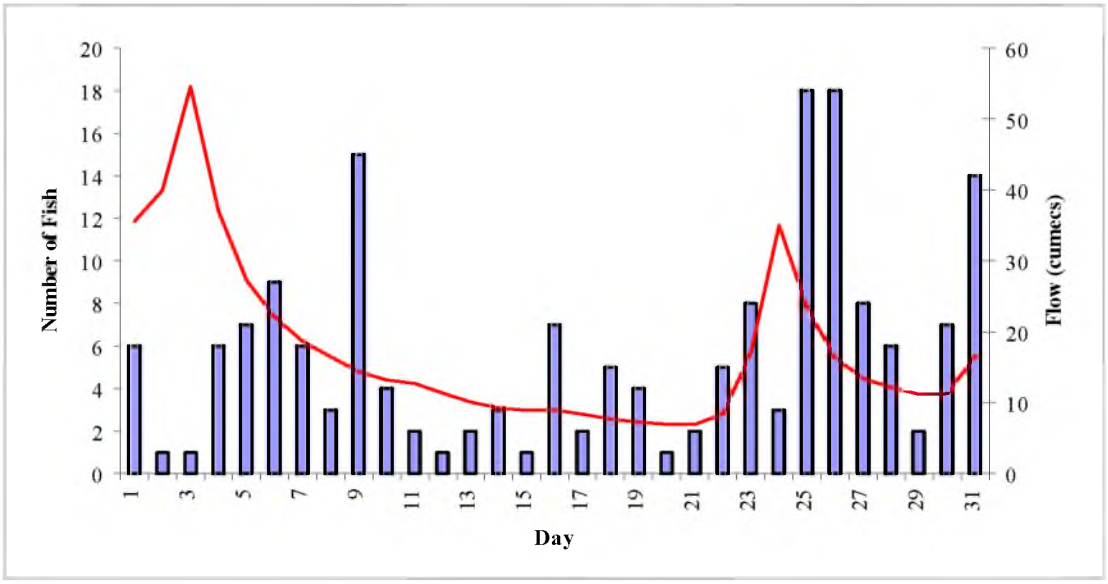


Figure 24 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – October 1999.

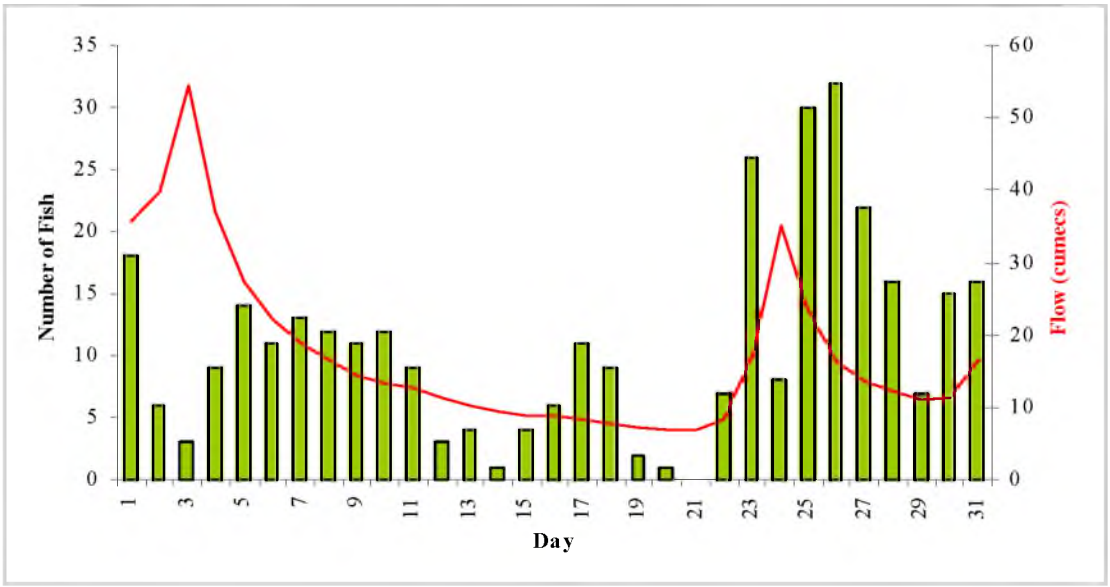


Figure 25 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – November 1999.

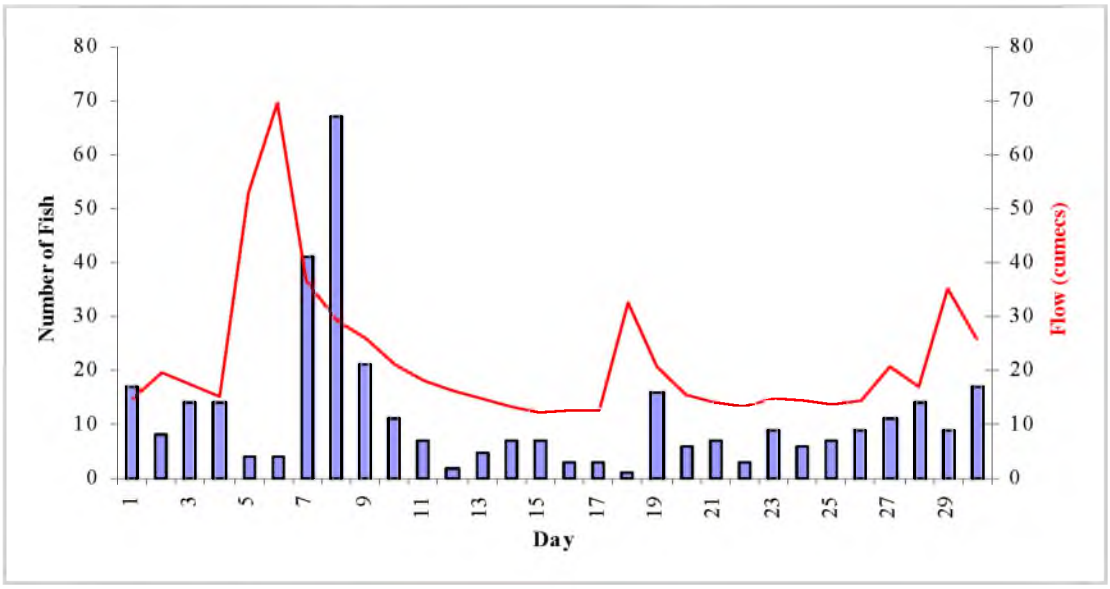


Figure 26 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – November 1999.

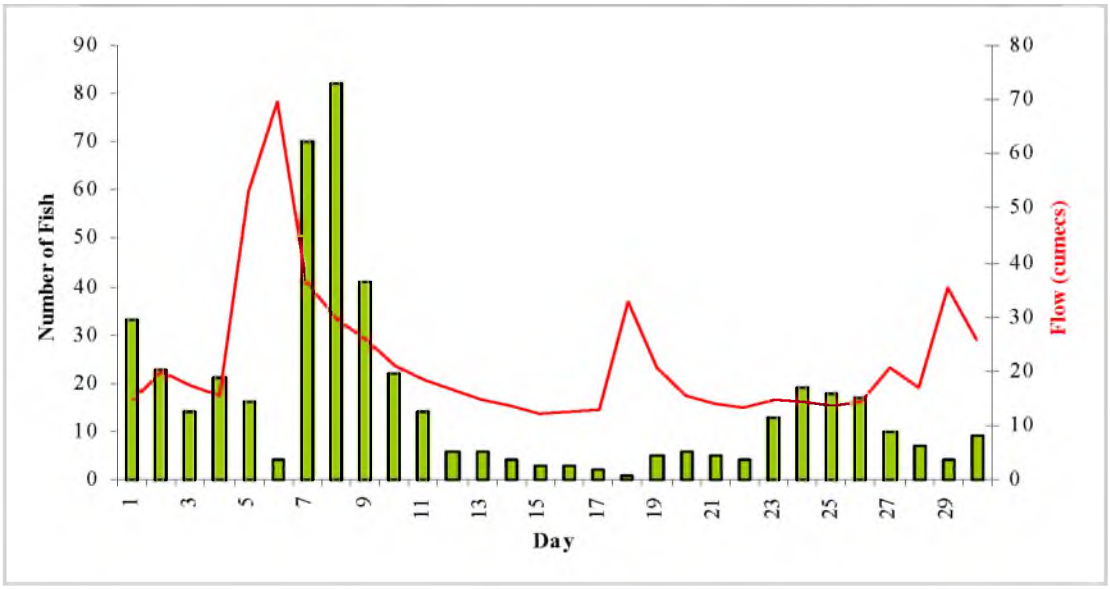


Figure 27 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – December 1999.

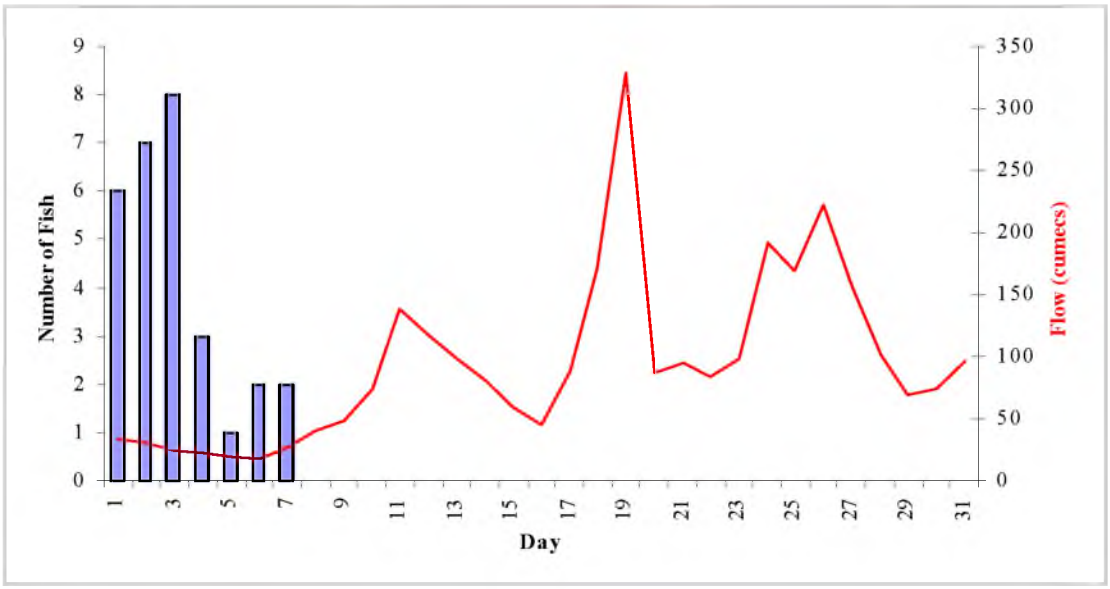
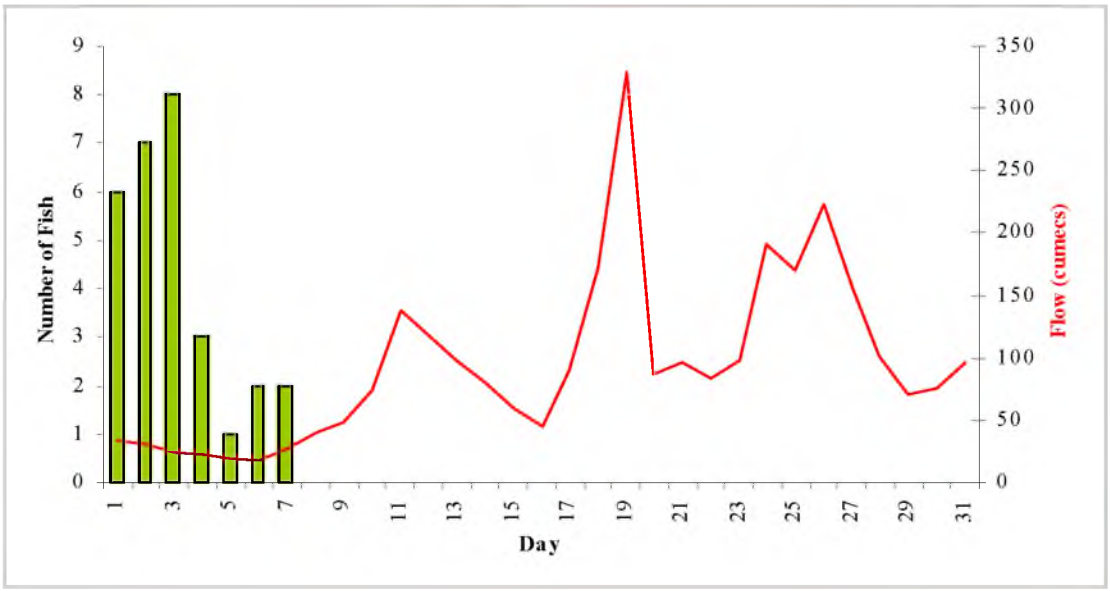


Figure 28 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – December 1999.



13. APPENDICES

Appendix 1 - Operating protocol for the Logie 2100A resistivity fish counter at Gunnislake Weir.

To detect fish passing upstream, the Logie 2100A utilises three stainless steel electrodes that are set into the downstream face of the fish pass at Gunnislake Weir. The construction of the fish pass ensures a smooth laminar flow of water over the electrodes and allows the fish to ascend the weir in close proximity to the electrode array. The electrodes are set into a polythene block to reduce fluctuations in resistivity due to the structure and between the electrodes.

The counter operates by applying a low positive/negative voltage (5 volts) at high frequency to the upper (+5 volts) and lower (-5 volts) electrodes. The net voltage at the central electrode is virtually zero as the two voltages effectively cancel each other out. As a fish passes over the bottom electrode it acts as a weak electrical conductor, causing an increase in the negative voltage at the central electrode. As a fish passes over the central and upper electrode it causes an increased positive voltage at the central electrode. The net result of a fish passing over the electrode array is a typical sine wave, the amplitude of the waveform being governed by the size of the fish.

The counter processes the signal received from the electrodes and uses an algorithm, together with pre-set parameters, to assess whether the object is a fish or not. If the positive and negative parts of the waveform are similar the counter recognises the 'event' as a fish and logs it as either an 'upstream' or a 'downstream' fish. The counter also records information connected to the event such as date, time, direction, water conductivity and signal strength (deflection signal size). If the deflection signal does not conform to that of a 'typical fish', it is logged as an event or discarded. In this way the counter can distinguish between fish and inanimate objects such as leaves and twigs.

Appendix 2 - Species Apportionment and Data Analysis

Species apportionment is made on the basis of the deflection signal size that is generated by the counter when a fish passes over the electrodes on the weir. The validation study conducted by the Environment Agency (1997) using video equipment to identify and measure fish traversing the weir found a linear relationship between fish length and deflection signal size. The study concluded that a deflection signal size of 50 could be used to differentiate between the majority of salmon and sea trout between June and February (88% of all fish greater than 50 cm attained a deflection size greater than 50).

Data from previous years indicated that larger sea trout run into the river from March – May. In order to eliminate these larger sea trout from the salmon count within this period, the deflection signal size to differentiate salmon from sea trout is increased to 70. It must be stressed that this relationship is not 100% accurate and that some large sea trout, those greater than 70 cm, may be counted as salmon.

Appendix 3 - Video Validation Strategy and Methodology.

- ***Video Validation Strategy.***

Video footage of fish movements is collected over the fish pass between April and August. This is when the greatest numbers of fish and a wide range of river flows are seen. The videotape is checked for quality before the operator leaves the site to ensure that any potential problems with picture quality or equipment failure are identified and rectified.

The aim is to carry out an initial review of each videotape within 7 days of collection. As each video is watched the "viewer" is required to complete a "video session recording sheet." This provides a record of each video session that the person has viewed and other relevant details e.g. picture quality, camera orientation etc.

- ***Video Viewing Sessions***

The videos are reviewed twice. Initially the tapes are watched 'blind' i.e. without referring to the counter data. The tapes are then reviewed a second time, over the same period, using the data from the counter, to highlight fish that may have been missed during the first review. This ensures an unbiased video count and an accurate video record of fish passage.

The watcher randomly selects, through the use of random number tables, two one-hour periods within each recorded video session. This acts as an initial screening of video data. Additional hourly periods may need to be reviewed to reach a required number of fish for statistical validity or because of poor picture quality etc.

Each period is viewed until an event i.e. fish, is seen. All events are identified. If it is a fish event then the fish is identified, where possible, and its total length and orientation (upstream/downstream) recorded.

- ***Video Event Sample Size***

As large amounts of video data are collected, a meaningful method of quickly and accurately reviewing footage collected has been developed. This is based on an assumption of counter efficiency and a level of confidence required for statistical validity. Comparing the numbers of salmon and sea trout recorded by the counter with the numbers on the video footage, an estimate of counter efficiency can be made.

The following method is used as a guide to assess how many fish per sample group are required for an estimate of the counter detection efficiency at different levels of precision and confidence. A sample group could be defined as either upstream migrating salmonids or even a single species. The same criteria can be applied for different species, size classes or environmental conditions. The level of confidence for the purposes of counter validation should be between 90 - 95%.

As an example, assume that we were interested in assessing the detection efficiency of the counter for:

- Upstream migrating salmonids
- At a confidence level of 95%
- At a precision level of 5%

If we also assume a counter efficiency of 50%*, then reading the information from Table A, we can see that we would need to have seen and recorded 384 upstream salmonids on the videotapes over the year. This means that a sample size of 384 fish is required to ensure with 95% confidence that the estimated efficiency will be within ±5% of the true estimate - Environment Agency R&D Technical Report (1997).

**Based on the lowest efficiency that we could expect.*

Table A – Sample size required at various levels of confidence and precision, assuming a 50% counter efficiency.

Precision	Confidence	90%	95%	99%
	0.01	6765	9604	16590
	0.05	271	384	664
	0.1	67	96	166
	0.2	17	24	42

Table extract taken from Environment Agency R&D Technical Report (1997).

To reach the given sample size, two one-hour periods per 24-hour period are randomly selected. The periods are reviewed and the number of upstream migrating salmonids within each one-hour period recorded. If the required sample size is not reached then additional one-hour periods can be reviewed until the required sample size is reached. In practice, all of the video footage for the year is first reviewed using the above technique. If, at the end of the tape review, the sample size for the whole year is below the required sample size or level of confidence/precision, then the tapes are reviewed again. This time, only one hour per day would be randomly selected until the required sample size is reached. Alternatively, a lower level of confidence, requiring a smaller sample size, could be selected.

- ***Matching Counter Data and Video Events***

To determine the efficiency of the:

i. Counter
ii. Video watching

During the second videotape review, the counter data is utilised to identify events that have been detected or missed by the counter. The video data is then matched to the corresponding counter data and recorded as one of the following:

- Upstream Fish - Salmon, Sea Trout or other species.
- Downstream Fish - Salmon, Sea Trout or other species.
- Upstream Event
- Downstream Event

Appendix 4 - Daily Movements of Salmon and Sea Trout Recorded at Gunnislake Fish Counter in 1999.